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ABSTRACT

A study of exceptional secondary school biology teachers was conducted to determine what factors might be important in encouraging young women to remain on the "science track" during high school. Each teacher had a record of encouraging his/her female students to enroll in further science and mathematics courses. Three questions were examined: (1) Males often score more positively on measures of science attitudes, interests, and past experiences. Would students of these teachers demonstrate similar sex-based biases?; (2) Would the student's race/ethnic group and school type/location have significant effects on these variables?; (3) How are these variables related to science and engineering career interest among male and female students? Measures were taken of students' science anxiety, attitudes toward science and scientists, cognitive style, locus of control, spatial visualization ability, participation in science activities, self-estimate of grade and ability, and attitudes toward women in science. Results indicate that the best predictor of science career interest for females was positive feelings about their science classes and that, compared to males, females expressed less confidence in their scientific and problem-solving abilities and reported less frequent participation in curricular and extracurricular science activities. Other findings (with implications for incresing females' science career interests) are reported and discussed. (JN)

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Science Career Interests, Attitudes, Abilities, and Anxiety Among Secondary School Students; The Effects of Gender, Race/Ethnicity, and School Type/Location

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Introduction

During the last decade, increasing numbers of women have chosen to pursue undergraduate and graduate science and engineering degrees (NSF, 1982 a & b). Unfortunately, the science attrition rates for both undergraduate and graduate women continue to exceed those of men (NSF, 1982 a & b; Graham, 1978). A parallel situation is often found at the secondary school level; young women often choose to avoid the "science track" and restrict their science and mathematics courses to those required for graduation. In order to determine what factors might be important in encouraging young women to remain on the "science track" during high school, the National Association of Biology Teachers' Committee on the Role and Status of Women in Science conducted case studies of exceptional secondary school biology teachers. Each teacher had a "track record" of encouraging his/her female students to enroll in further science and mathematics courses. Results of the individual case studies are reported in Kahle (1983 a & b).

In addition to the qualitative data described in the individual case study reports, quantitative survey data was collected on students in the case study teachers' classrooms. Analyses of these data are the subject of this report. Three questions were examined:

1) Males often score more positively on measures of science attitudes, interests, and past experiences. Would the students of the case study teachers demonstrate similar gender-based biases?

2) Would race/ethnic group of the students and type/location of the school have significant effects on these variables?

3) How are these variables related to science/engineering career interest among male and female students?

Methods

Sample

The students, constituting the study sample, were enrolled in biology courses taught by exceptional teachers. The teachers were chosen for a national study on the retention of girls in science because each had a proven record of encouraging female students to continue in science courses and to pursue scientific careers. Overall, 408 secondary school students from

seven high schools in seven states completed a battery of instruments. The students were primarily high school freshmen (23.9%) and sophomores (63.0%).

Students in the sample identified themselves as white (73.9%), black (18.9%), Hispanic (3.7%), or Asian/Pacific Islander (1.4%). There were no gender differences in racial distribution but, as shown in Table 1, the schools varied considerably in racial composition. In general, the urban Illinois and suburban Louisiana schools had predominantly black students; the suburban Missouri and urban Colorado schools as well as all rural schools, had predominantly white students; while a mixture of white and Hispanic students were found in the urban Texas school.

When students in the sample were asked to estimate their usual grades in school, 12.2% responded "excellent;" 42.9% responded "above average;" 43.2% indicated "average;" and 2.6% indicated "below average." Estimates of grades did not differ between males and females.

Procedure

All instruments were distributed and collected by the classroom biology teacher in the spring semester of 1983. Students were assured that their responses were confidential and their teacher would neither grade the scales nor receive any report of their individual responses. Nearly all (93%) of the students returned completed surveys; the final sample consisted of 205 females and 147 males. Surveys and instruments measured the following variables: Science anxiety (Alvaro, 1978); attitudes toward science and scientists (Motz, 1971); cognitive style (Ekstrom, French, Harman, & Derman, 1976); locus of control (Phares, 1957); spatial visualization ability (Thurstone & Jeffrey, 1956); and participation in science activities (Kahle & Lakes, 1983). In addition to these instruments, an additional student survey, modeled after those of Erlick and LeBold (1977), was designed to collect certain demographic data, determine students' self-estimates of their grades and abilities, and assess attitudes toward women in science. Some of the measured variables are listed in Table 2.

Results

Statistical Concerns

Two statistical concerns arose during analysis of the student response

data. First, several scales offered Likert-type response options. Analyses of male and female responses to each option provided evidence of a gender-based response bias. On certain surveys, females chose "undecided" or central responses significantly more often than did males, while males chose the extreme responses significantly more often than did females. Because of these differences, when scales were scored by summation of response values, gender differences in response patterns were masked. An alternate scoring method was used in these cases; the scale score equalled the total number of "strongly agree" or "agree" responses (or the two most "positive" responses).

The second statistical problem arose while attempting to compare responses of the study sample with those of a national sample, specifically the responses of 17-year-olds to the 1976-77 National Assessment of Educational Progress (NAEP) survey of science. Because the two samples differed in size and specific composition, they could not be directly compared. However, similar statistical procedures were used for making comparisions within each group. For example, standard errors of response percentages for each item were calculated (Snedecor & Cochran, 1983), as was done in the NAEP surveys. In both surveys, differences of greater than two standard errors were considered significant.

Student Characteristics

In general, the students in this sample had low levels of anxiety positive attitudes toward science and scientists, an internal locus of control orientation, positive feelings about their science classes, infrequent contact with counselors, and moderately frequent extracurricular science activities. Even when loosely compared, the students in this sample, compared to those in the 1976-77 NAEP sample, had more positive science attitudes, greater numbers of both curricular and extracurricular science experiences, and greater interest in science careers. Over 70% of students in this sample, compared to less than 40% in the NAEP sample, indicated that they were interested in science-related careers. However, gender differences in career interest were evident in both samples; males expressed greater interest in science-related careers than did females.

Analyses by Race, Gender, and School

The variables listed in Table 2 were examined for differences by gender, race, and school. Since the schools were geographically and socio-economically diverse, differences by school undoubtedly reflect these variables as well. In general, the variables differed more often by school than by race or gender. As indicated in Table 3, students in the urban Colorado school expressed the most positive attitudes toward science and scientists, the greatest performance/precision anxiety, and the most independent mode of cognitive style.

The suburban Missouri school students earned the highest scores on measures of spatial ability, feelings about science classes, participation in curricular science activities, willingness to fund scientific research projects; and parental educational levels while earning the lowest scores on science and non-science study test anxiety subscales. Students in rural Indiana reported low average grades, more negative feelings about science classes, fewer curricular experiences, and less willingness to support scientific research yet expressed positive attitudes toward science and scientists and low levels of performance/precision and test anxiety. The urban Illinois students received low scores on the spatial ability measure, had low average grades, and reported low parental educational levels.

The urban Louisiana school students expressed the greatest science and non-science study test anxiety and, along with the urban Texas students, the most negative attitudes toward science and scientists. The urban Texas students also received the lowest scores on the spatial ability measure, had the most field-dependent mode of cognitive style, had fewer curricular science experiences, and reported low parental educational levels but high average high school grades.

The main effect of student racial/ethnic group was significant for scores on the practical precision anxiety subscale, students' attitudes toward women in traditionally masculine careers, father's educational level, frequency of contact with counselors and perceptions of whether or not women should be employed (Table 4). Scheffe tests ($p < .05$) indicated that Asian/Pacific Islander students' fathers had the highest level of education, white and black students' fathers had the second highest levels, and Hispanic students' fathers had the lowest educational levels.

Finally, the main effect of gender was significant for only six variables (Table 5). Females expressed greater science study test anxiety and observer anxiety, less confidence in their scientific and problem-solving abilities, and less frequent participation in curricular and extracurricular science activities.

Race by gender interactions were significant for six of the eight anxiety subscales, for both of the science attitudes scales, and for the measures of father's educational level, curricular and extracurricular activity participation and willingness to support research. Race by gender interactions could be accounted for primarily by the responses of the Hispanic students. Hispanic females expressed high laboratory and science study test anxiety, less positive attitudes toward science and scientists, less willingness to support research, and infrequent participation in curricular and extracurricular science activities. In contrast, their male cohorts expressed low anxiety on all six subscales, greater willingness to support research, and frequent participation in curricular and extracurricular activities.

Black males and females responded quite similarly to most questions. Black males did, however, express greater memory anxiety than did black females. Like the black students surveyed, white males and females responded similarly on most variables. White males did, however, report greater performance/precision anxiety and more frequent curricular science activity participation than did their female cohorts.

Several race by school interactions were significant. However, with the exception of the Texas school, the racial composition of each school was quite homogeneous and, consequently, the number of students in many race X school cells was zero or small. This made the race by school interactions difficult to interpret.

Science/Engineering Career Interests

Each student was also asked a series of four questions about his/her interest in a science or engineering career. These questions were distributed among two of the survey instruments. A "science career interest score"

was computed by summation of the response values for these questions. Stepwise multiple regression analyses were conducted for both males and females to determine which variables were most closely related to science/engineering career interest. Results are reported in Table 6.

The best "predictor" of science career interest among young women was positive feelings about their science classes, accounting for 22.6% of the variance in interest scores. Other significant and positive contributors to the regression equation for science career interest were greater drive to achieve, better problem-solving and scientific abilities, participation in extracurricular science activities, and positive attitudes toward women in science. Science career interest was also related to external locus of control.

For males, positive attitudes toward women in science was the best "predictor" of science career interest. Greater performance/precision anxiety, better scientific and mathematical abilities, and frequent participation in curricular and extracurricular science activities also were related to science career interest and made significant contributions to the regression equation. Greater contact with an academic counselor, however, was negatively related to science career interest. Both the regression equation for males and for females accounted for significant proportions of the variance in science career interest scores (47.8% and 73.3%, respectively); the equation for male students, compared to the one for female students, accounted for a greater proportion of the variance.

Discussion

Previous research had indicated that male and female adolescents usually differ on measures of some attitudinal and personality variables related to science interest and science achievement. Males have been found to have a more field-independent mode of cognitive style (Witkin & Goodenough, 1981), better spatial abilities (Maccoby & Jacklin, 1974), a more internal locus of control (Lefcourt, 1976), and better science attitudes (Kahle & Lakes, 1983). According to the present study, however, gender differences on these variables are not significant. The female students surveyed, all enrolled in introductory biology courses taught by exceptional teachers, scored similarly to their male cohorts on those traits and attitude measures. Females were, however, somewhat more anxious about being observed while doing laboratory activities, and about

studying for science exams. In fact, prior research has found that females frequently express greater test anxiety than do males (Tobias, 1978). The young women in this study, compared to the young men, also expressed less confidence in their scientific and problem-solving abilities and reported less frequent participation in curricular and extracurricular science activities. These findings agree with those of the 1976-77 and 1982 National Assessments of Educational Progress findings (Kahle & Lakes, 1983; Hueftle, Rakow, & Welch, 1983).

Differences among students in various participating schools were found to be more important than gender within a given school or in the total sample for most of the examined variables. Whether the school differences reflect teacher and curriculum differences, community type, geographic location, socio-economic status of the school population, or a combination of all of those factors is not known. Generalizations were difficult to draw. It appears, however, that students in midwestern schools expressed the lowest science study test anxiety and performance/precision anxiety while southern students reported the highest science study test anxiety.

Racial/ethnic group of the student was closely related to his/her father's educational level but to few other variables. Race by school interactions were often significant, but difficult to interpret. In all but one school, the student sample was composed of primarily one racial/ethnic group. One would expect, therefore, that either race or school would be a factor, but not both. The significance of race by school interactions may be partially accounted for by the diversity of the types of school within each racial group. For example, the two black student samples in the urban Illinois and urban Louisiana schools differed considerably in future educational plans, average socio-economic levels, and parental educational levels. The Louisiana school is a laboratory school associated with a university while the Illinois school is a magnet school in an underprivileged area. Similarly, several of the schools composed of primarily white students differed in average socio-economic status and typical post-high school plans of students. For these reasons, race and school represented different factors even though the student body in each school was composed of primarily one racial/ethnic group. Unfortunately, the small sample size in many cells made clear interpretations difficult.

Multiple regression analyses using science career interest as the "dependent" variable indicated that different variables were related to science career interest among young men and women. Surprisingly, among young men, a liberal attitude toward the role of women in scientific professions was strongly related to science career interest. This may reflect the positive attitudes expressed in class by the case study teachers. Other related variables reflect career interest based on "traditional" factors; perceived abilities, past experiences in and out of class, and a concern about being precise and accurate in laboratory and other activities.

For young women, however, feelings seem to play a larger role. Females' positive feelings about their science classes and about women in science as well as their acheivement motivation were related to greater science career interest. According to these data, when science classes make young women feel curious, confident, and successful, not "stupid" and afraid to ask questions, their career interests are correspondingly higher. Although these data are no indication of causality, they raise interesting questions for future experimental research. If young women's positive feelings about science classes and the participation of women in science as well as their problem-solving abilities and their achievement motivation can be fostered, then their science career interests may be increased.

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Table 1

Descriptions of Sample Schools by Geographic Location, Community Type, and Predominant Racial Group

Geographic Location	Small Town/Rural	Suburban	Urban/Small City
South	------	Louisiana: Predominantly black (95%) (N = 43)	Texas: Mixed white (46%) & Hispanic (41%) (N = 22)
Midwest	Indiana: Predominantly white (96%) (N = 68)	Missouri: Predominantly white (95%) (N = 102)	Illinois: Predominantly black (87%) (N = 23)
Northeast	Maine: Predominantly white (96%) (N = 51)	------	--------
West	-------	------	Colorado: Predominantly white (91%) (N = 44)

Table 2

Mean Scores for Measured Variables

Variable	$\bar{X}$	std.dev	N	Min/Max*	High score indicates
Ability/Aptitude					
Spatial ability	67.58	29.308	408	0/126	greater ability
Average grades	2.64	0.726	353	1/4	higher grades
Academic ability	2.29	0.956	350	1/5	lower ability
Scientific ability	2.67	1.068	353	1/5	lower ability
Problem-solving ability	2.56	1.046	353	1/5	lower ability
Attitudes					
Toward science	12.05	4.719	408	0/21	positive attitudes
Toward scientists	17.90	7.967	408	0/30	positive attitudes
Toward women in science	13.14	7.289	353	4/24	negative attitudes
Toward women's employment	2.03	0.917	350	1/5	career orientation
Feelings about sci. class	2.50	2.270	350	0/6	positive feelings
Support for research	3.91	3.370	350	0/10	willingness to support
Drive to achieve	2.14	1.035	350	1/5	less drive
Interest in Science Career	8.54	3.290	216	4/14	less interest
Anxiety					
Laboratory	7.71	3.075	323	5/25	higher anxiety
Science Study Test	5.31	2.455	328	2/10	higher anxiety
Quantitative Conversion	5.13	2.369	332	3/15	higher anxiety
Observer	13.65	5.366	314	7/35	higher anxiety
Non-science Study Test	4.82	2.385	329	2/10	higher anxiety
Memory	3.98	2.046	332	2/10	higher anxiety
Performance/Precision	24.72	8.033	307	14/70	higher anxiety
Practical Precision	2.74	1.323	333	2/10	higher anxiety
Personality/Personal					
Cognitive style	9.69	6.516	408	0/32	field-independence
Locus of Control Orient.	10.52	6.295	408	0/40	external orientation
Extracurricular Sci. Act.	2.03	2.350	350	0/7	more activities
Curricular Science Act.	11.08	9.238	350	0/28	more activities
Counselor Contact	3.73	2.023	350	2/8	more contact
Father's Educational Level	3.48	1.290	353	1/5	higher education
Mother's Educational Level	3.19	1.152	350	1/5	higher education

*Minimum and maximum possible score

Table 3

Main Effects of School on Measured Variables and Subsequent Scheffe Test Groupings*

Ability/Aptitude

Spatial Ability: df=6,313; F=2.108; p=.052

IL	TX	LA	IN	ME	CO	MO

Average Grades: df=6,313; F=6.119; p=.001

IL	IN	ME	LA	CO	MO	TX

Attitudes

Attitudes Toward Science: df=6,313; F=2.822; p=.011

TX	LA	IL	ME	MO	IN	CO

Attitudes Toward Scientists: df=6,313; F=6.568; p=.001

TX	LA	IL	ME	MO	CO	IN

Anxiety

Science Study Test Anxiety: df=6,243; F=3.770; p=.001

IL	IN	MO	ME	TX	CO	LA

Non-science Study Test Anxiety: df=6,243; F=2.205; p=.043

IN	MO	TX	IL	ME	CO	LA

Performance/Precision Anxiety: df=6,243; F=6.202; p=.001

IN	IL	MO	ME	TX	LA	CO

Personality/Personal

Cognitive Style: df=6,313; F=7.049; p=.001

TX	IL	LA	IN	MO	ME	CO

Father's Educational Level: df=6,313; F=9.723; p=.001

IL	TX	IN	LA	CO	ME	MO

Mother's Educational Level: df=6,313; F=5.491; p=.001

TX	IL	IN	CO	ME	LA	MO

*Groupings are shown only for those variables which the Scheffe test (p=.05) divided into two or more groups.

Table 4

Main Effects of Race/Ethnicity on Measured Variables and Subsequent Scheffe Test Groupings*

Variable	df	F	p
Practical Precision Anxiety	4,243	5.315	.001
Attitude Toward Women in Sci.	4,313	6.384	.001
Father's Educational Level	4,313	5.463	.001
Attitude Toward Women's Employment	4,313	3.380	.010
Counselor Contact	4,313	7.813	.001

Father's Educational Level

Hispanic	Other	Black	White	Asian/Pacific Islander

Counselor Contact

Hispanic	Black	White	Asian/Pacific Islander	Other

*Groupings are shown only for those variables which the Scheffe test (p=.05) divided into two or more groups.

Table 5

Main Effects of Gender on Measured Variables

Variable	df	F	p	Male Mean	Female Mean
Science Study Test Anxiety	1,243	9.130	.003	4.77	5.72
Observer Anxiety	1,243	4.038	.046	12.86	14.34
Scientific Ability	1,313	5.300	.022	2.51	2.78
Problem-solving Ability	1,313	6.650	.010	2.38	2.64
Extracurricular Science Activities	1,254	10.099	.002	2.51	1.69
Curricular Science Activities	1,254	4.383	.037	12.30	10.19

Table 6

Multiple Regression Analyses of Science Career Interest Scores for Male and Female Students

Variable Entered*	sig.	R	R^2	simple R
MALES				
Attitudes Toward Women in Sci.	.000	.473	.224	.473
Scientific Ability	.000	.624	.390	.376
Performance/Precision Anxiety	.007	.684	.468	-.259
Counselor Contact	.003	.742	.551	.418
Curricular Science Activities	.004	.786	.618	-.230
Mathematical Ability	.007	.819	.670	.068
Extracurricular Science Act.	.047	.834	.696	-.468
Memory Anxiety	.118	.843	.711	-.096
Practical Precision Anxiety	.058	.856	.733	-.189
FEMALES				
Feelings About Science Class	.000	.476	.226	-.476
Drive to Achieve	.007	.535	.286	.325
Locus of Control	.007	.584	.341	-.116
Attitudes Toward Women in Sci.	.026	.614	.376	.226
Non-science Study Test Anxiety	.065	.632	.400	-.050
Extracurricular Science Act.	.036	.655	.430	-.353
Problem-solving Ability	.041	.675	.456	.139
Scientific Ability	.059	.692	.478	.380

* Both analyses have variables entered in a stepwise manner.